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POSSIBLE RELATION BETWEEN THE MÜLLER'S MAP OF BOHEMIA AND THE FIRST MILITARY SURVEY — A CASE STUDY OF THE KLADNO REGION

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The Müller's map of Bohemia originated in the years 1712 till 1718 as the result of the first systematic topographic mapping of the Czech lands. This map served as a base for the First Military Survey realized 1763–1787 on the area of the whole Habsburg Empire. The paper presents a study of relations between the Müller's map of Bohemia and the maps from the First Military Survey from the region near the town Kladno in the Central Bohemia. The sections of the above mentioned old maps in electronic form have been used for accuracy analysis of selected points located within the test area. The same area has been investigated on the present topographic map of the Czech Republic (scale: 1:25 000). The centres of 39 settlements have been identified in all compared maps and their rectangular plane co-ordinates have been recorded. For the analysis, affine transformation was applied on the point co-ordinates. The presented results may contribute to the discussion on the positional accuracy of these old maps and on the way our predecessors used for mapping of the Czech Lands in the 18th century.

Keywords: First Military Survey; Müller's map of Bohemia; old maps; topographic map

Introduction

The maps of historical as well contemporary Czech Lands, i.e. Bohemia, Moravia and the Czech part of Silesia originated probably as a part of mapping of the Middle-European area at the beginning of the 2nd millennium, what results from some written sources. The first preserved map documents appeared up to the 16th and 17th centuries as the works of individual cartographers (Claudianus, Criginger, Fabricius, Comenius, Helwig and others) who necessarily based their maps on older map sources with a high informative value (Kuchař 1961). Systematic mapping

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based on simple measuring methods appeared approximately hundred years later in the works of J C Müller.

Müller's mapping of the Czech Lands in the 18th century

The first systematic mapping of the Czech Lands was done by the Austrian military imperial engineer, surveyor and cartographer Johann Christopher Müller, who lived in the years 1673–1721. He studied mathematics and map drawing by the Nürnberg astronomer and copper engraver G C Eimmart. After that he changed to military service at the imperial colonel L F Marsigli, an excellent natural scientist and geographer. Under his guidance Müller carried out astronomical measurements in Hungary and after the peace, concluded by Austria with Turkey in the year 1699, the mapping of new border areas, which fell to Austria. In 1708 he was entrusted by the elaboration of a big map of Hungary at scale 1:550 000, which included the territory of Slovakia as well.

Müller's further goal was to prepare a big atlas of the Austrian lands (*Atlas Austriacus*). The mapping began on the territory of Moravia, which was charted during the years 1708–1712 by individual regions at scale 1:180 000 and it was issued on four map sheets. For mapping he used geodetic points, their positions were measured astronomically. For drawing of topography he used the compass and the distances he measured by the number of turns of wheels of measuring cars pulled by horses.

The most popular work of Johann Christopher Müller is his map of Bohemia at scale 1:132 000, which consists of 25 map sheets in the size 557×473 mm. The whole territory of Bohemia takes up the total area of 2822 x 2403 mm. The map includes 12 493 settlements and contemporary administrative division of Bohemia into 12 regions. The map is drawn in the Cassini cylindrical projection with marked geographical meridians and parallels. The Müller's map of Bohemia includes the division of settlements into 10 basic categories (royal and other towns, towns with ramparts, townships, castles, mansions and knight palaces, small towns with castle and church, villages with castle, villages with and without church, individual farmyards, passable villages and scattered settlements). Further there are monasteries and lonely standing churches and farm buildings. Depicted are rivers and ponds, the altimetry is shown by the hill method. The thematic content of the map is very rich and it shows mining areas of various raw materials, glass factories, ferries, postal stations, medicinal and thermal springs, tilt-hammers, water mills, roads and vineyards. Geographical names are in German.

The mapping proceeded step by step in individual regions until January 1718, when the fair draughts of all map sheets were finished. Then the maps were handed over to the regional commissioners for revision. As this action run into difficulties, Müller did the final revision himself and finished the final fair drawings in 1720 (incl. a map layout, called "*compendium*"). The copper engravings were done by the engraver M Kauffer from Augsburg, who completed the maps by valuable engravings from V V Reiner. At the beginning of 1721 Müller checked the engravings of the first 12 map sheets, but he did not live to see the printing of these maps, because he

died in June 1721. Then the works were taken over by a military engineer Johann Wolfgang Wieland.

The Müller's map of Bohemia is one of the most beautiful and very valuable cartographic works. It exists in a relatively large number of copies and is saved in many state and private archives and collections. It presents not only the evidence of the cartographic culture of our ancestors, but it is as well an important study material reflecting the development and culture of our lands on the beginning of the 18th century. The map is saved e.g. in the Map archive of the Historical Institute of the Czech Academy of Sciences and in digital form it is available on a CD.

The First Military Survey

Müller's maps of Bohemia and Moravia are the first completed map work of the Czech Lands and they are the only maps available to the commanding officers of the Austrian army during the Seven Years' War (1756–1763). While these maps step by step outdated and insufficiently corresponded to the needs of the military affairs and the development of the military techniques, the Empress Maria Theresa decided to elaborate a new integral map work of the whole territory of the Austrian Monarchy at scale 1:28 800. The scale was derived from the demand that the distance of one Viennese inch in the map should equal to the distance of 400 Viennese fathoms (i.e. 758.6 metres) in the reality, what corresponded to 1000 military marching steps.

The First Military Survey was realized in the years 1763–1787. This mapping is also called Joseph's mapping, because it was finished by the reign of the Emperor Joseph I. As a graphical base for the mapping supposedly the enlargements of the Müller's maps were used (Boguszak and Císař 1961) with graphically measured geodetic points which Müller had determined astronomically. The mapping was done without any other geodetic control, in continuous map layout and supposedly with minimum of measuring. The territory of the whole Empire was covered by 5400 map sheets each of them included the area of approx. 209 km^2.

The field mapping was done by imperial officers — military engineers, usually at a guess by riding on horses in the landscape ("*à la vue*" method), only some details were measured by spacing (Kretschmer et al. 2004). The map content included settlements, roads and stone bridges, rivers, meadows, forests and grasslands. The settlements were depicted topographically, by their planimetric plans. The altitude was presented by hachures, which indicated the topography of foots of significant terrain slopes. For every map, a set of descriptive information was elaborated, which contained data about the passableness of forests and swamps, the possibilities of troops accommodation in the villages and the numbers of draught animals and animals for slaughter.

The mapping of Bohemia was realized in the period 1763–1767 (273 map sections), of Moravia in the period 1764–1768 (126 map sections). During the war about the Bavarian inheritance (1778–1779) some deficits of the maps became evident. Therefore a map revision was initiated, especially in the area of Northern Bohemia. In this area, a new mapping of more than 140 map sections was later realized (1780–1783). All the map sections are deposed in the War Archive of the Austrian State Archive in Vienna (Österreichisches Staatsarchiv, Kriegsarchiv).

The study area and the used methods

The first part of the research on possible relation of the above mentioned old maps — at the test area near Jindřichův Hradec (Southern Bohemia) — was done by Mikšovský and Zimová (2005) within the research project at the Department of Mapping and Cartography, CTU Prague. A similar approach has been implemented now for the region of Kladno in Central Bohemia in order to get results from another part of the territory and verify the conclusions. The general idea was to compare the positions of settlements (towns, villages) within the test area depicted on the Müller's map, the maps from the First Military Survey and the present Basic Map of the Czech Republic at scale 1:25 000.

The tested region lies in Central Bohemia and covers the area approx. 14×16 km. The surroundings of the town Kladno was originally an agriculture area. Since the middle of 19th century, a fast growing mining (black coal), metallurgy and steel industry appeared. At present, the Kladno agglomeration represents the largest industrial and urban area in Central Bohemia. The landscape of the region is partly the upland with forest and mild hills (300–400 m above the sea level), mostly forestless agriculture area with short watercourses. The position of the test area is seen in Fig. 1.

Kladno is on the Müller's map depicted in the left lower corner of the section VIII and marked by the map sign as the "village with a castle". The considered test area is situated on corresponding parts of four map sections (VII, VIII, XII, XIII). In an electronic montage it was discovered that Kladno is depicted on both neighbouring map sections — it means twice on the Müller's map as it is seen on the Fig. 2. For further research the location of Kladno was taken into account to be in the middle of the connection line between both cartographic signs. On the maps of the First Military Survey the region of Kladno is depicted on the sections 89 and 106 (raster files provided by Geoinformatics Laboratory, University of J E Purkyně – http://www.geolab.cz). A sample of this map is shown in Fig. 3. For comparison with contemporary situation, the scanned sheets 12-231, 12-232, 12-233, 12-234 of the Basic Map have been used (raster files provided by the Czech Office for Surveying, Mapping and Cadastre).

The corresponding maps sheets in electronic form were merged together in the KOKEŠ software: map sheets of the Müller's map and the First Military Survey were merged on the map sheet frames, the sheets of the Basic Map were georeferenced using the S-JTSK (the national grid of the Czech and Slovak Republics) co-ordinates of the maps sheet corners. For processing in the KOKEŠ software it was necessary to enlarge electronically each raster file into the scale 1:1. Then, a correct relation of the visualized raster file and the KOKEŠ co-ordinate system has been ensured, i.e. a real distance of one meter, depicted on the raster map, has been represented as one meter distance in the co-ordinate system.

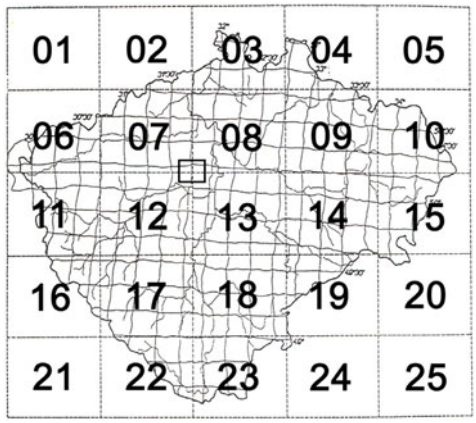

Fig. 1. Position of the test area Kladno (marked by the black rectangle) on the sections layout of the Müller's map of Bohemia

Fig. 2. Depiction of the town Kladno on neighbouring map sections of the Müller's map

Positioning of locations and transformations

Within the researched area 39 settlements depicted on all three map types were identified and their positions have been recorded. It is necessary to mention, that on the Müller's map the settlements are depicted only using a point map sign, while in the maps of the First Military Survey (and of course as well in the Basic map) they are depicted by the planimetry of the settlements. The corresponding points were therefore selected as follows: for the Müller's map, the centres of the map symbol (a circle), for the First Military Survey and the Basic map, a supposed centre of depicted planimetric plan of the village/town (main square, crossing, church etc.) have been considered.

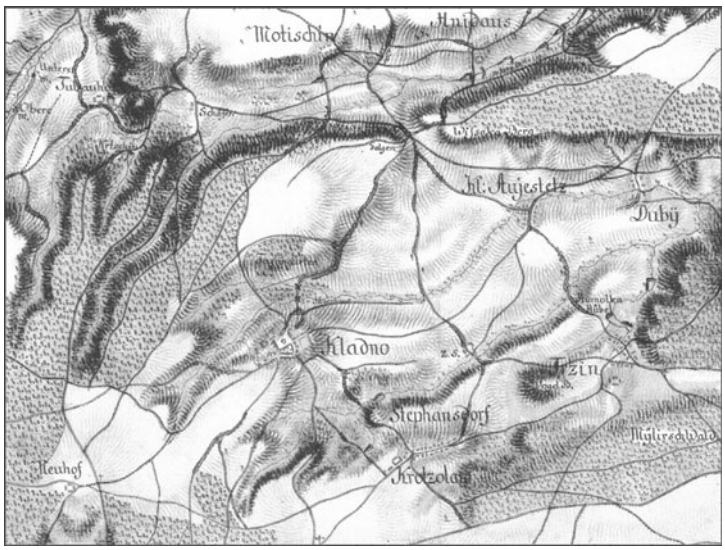

Fig. 3. Kladno and its surroundings on the First Military Survey

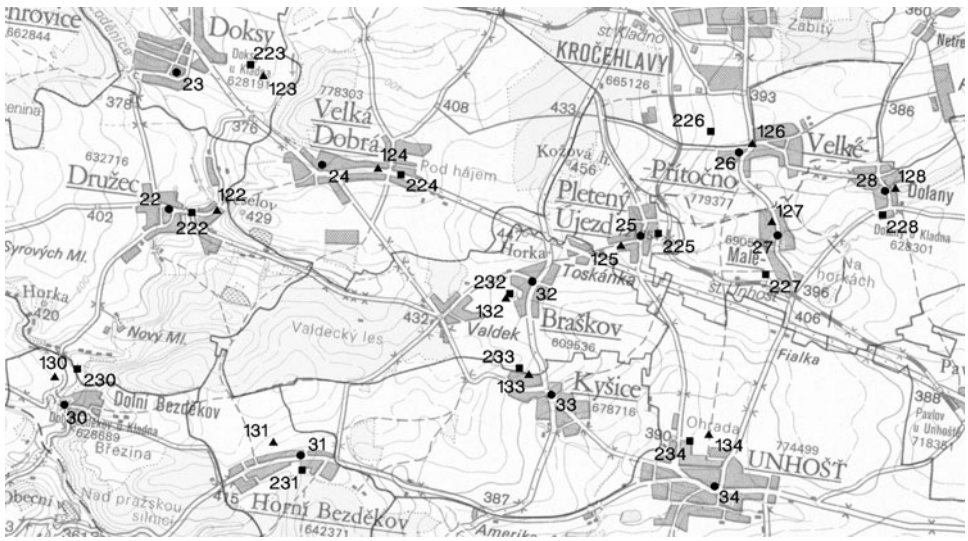

Fig. 4. Positioning of seats on the old maps after the first transformation to the Basic map (a part of the test area). Used signs and numbering of points: • Basic Map (1, 2, . . .); ▲ First Military Survey (101, 102, . . .); ■ Müller's map (201, 202, . . .)

The first transformation applied was an affine transformation done using the co-ordinates of 39 identical points — it means all the recorded locations within the test area. These co-ordinate sets were transformed from the two old map system to the S-JTSK co-ordinates of the modern Basic map and also from the First Military Survey

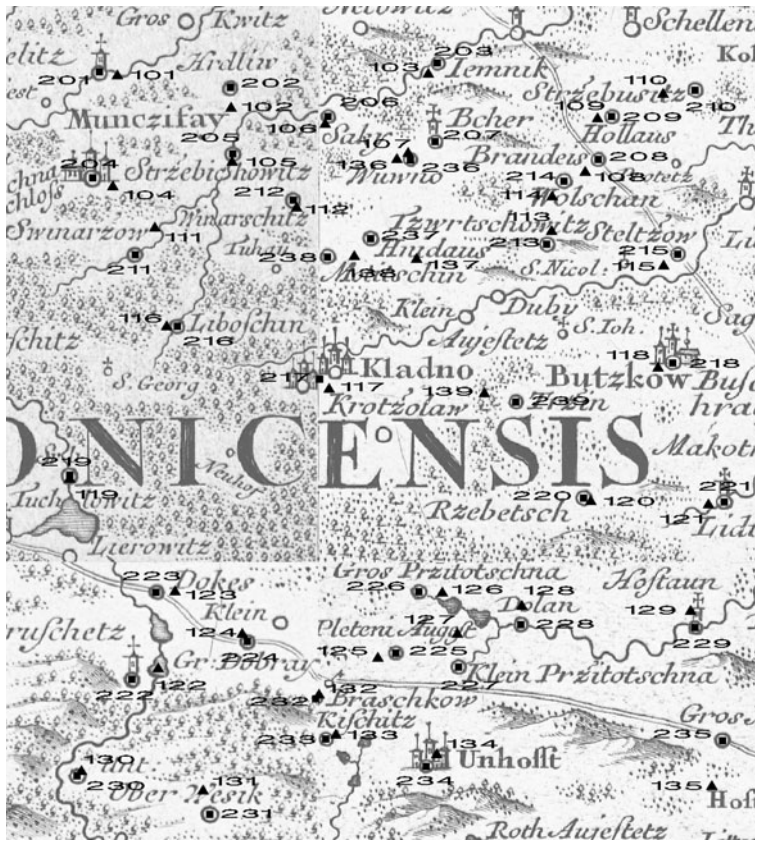

Fig. 5. Positioning of seats on the First Military Survey after the first transformation to the Müller's map. Used signs and numbering of points: ▲ First Military Survey (101, 102, ...), ■ Müller's map (201, 202, ...)

to the Müller's map. The second kind of transformation used just four identical points selected after the first transformation — the idea behind this was to avoid minimizing the probable discrepancies of old maps by transformation adjustments. All the data processing was done in the KOKEŠ software. The transformed positions of settlements have been depicted in the Basic map (Fig. 4) and in the Müller's map (Fig. 5).

Following the transformations, the depiction of the settlements on old maps have been compared calculating the positional deviation for corresponding points and the mean position error of the whole set of co-ordinates using the following formulas (Zimová et al. 2006):

$$dP = \sqrt{dX^2 + dY^2} \tag{1}$$

dP (m) – positional deviation (shift) of the point,
dX (m) – difference in X-co-ordinate,

Table I. The list of the settlements with their corresponding positional errors

Name of the seat (and number) on the		Positional shift in metres (S-JTSK)					
Müller's map	Basic map	Müller's map – Basic map			First Milit. Survey – Basic map		
		dY	*dX*	*dP*	*dY*	*dX*	*dP*
Przelitz (201)	Přelíc (1)	–587	–193	618	–442	–193	482
Hrdliw (202)	Hrdlív (2)	–354	404	537	–469	140	490
Iemnik (203)	Jemníky (3)	389	–125	409	289	–161	331
Munczifay (204)	Smečno (4)	–577	–66	581	–422	–217	475
Strzebichowitz(205)	Třebichovice (5)	–491	193	527	–616	138	632
Saky (206)	Saky (6)	–106	137	173	–175	118	211
Bcher (207)	Pchery (7)	380	–135	403	–73	–164	179
Brandeis (208)	Brandýsek (8)	334	83	344	283	1	283
Hollaus (209)	Holousy (9)	242	–144	282	208	8	208
Strzebusitz (210)	Třebušice (10)	809	–10	809	504	164	530
Swinarzow (211)	Svinařov (11)	–248	–687	731	–2	–183	183
Winarschitz (212)	Vinařice (12)	–296	712	771	–300	645	712
Tzwrtschowitz (213)	Cvrčovice (13)	–116	–455	470	165	–125	207
Wolschan (214)	Olšany (14)	187	–240	304	111	–394	409
Steltzow (215)	Stehelčeves (15)	–146	438	462	–171	351	391
Liboschin (216)	Libušín (16)	235	–661	701	–134	–611	626
Kladno (217)	Kladno (17)	–342	868	933	–229	666	704
Butzkow (218)	Buštěhrad (18)	–231	9	231	–279	16	279
Srb (219)	Srby (19)	826	–804	1152	543	–917	1066
Rzebetsch (220)	Hřebeč (20)	64	–444	449	342	–527	629
Liditz (221)	Lidice (21)	56	–751	753	20	–755	756
Druschetz (222)	Družec (22)	239	–34	242	505	–8	505
Dokes (223)	Doksy (23)	776	81	780	909	–36	910
Gr.Dobray (224)	Velká Dobrá (24)	824	–104	831	587	–35	588
Pleteni Augest (225)	Pletený Újezd (25)	183	25	185	–210	–101	233
Gros Przitotschna (226)	Velké Přítočno (26)	–293	223	368	141	95	170
Klein Przitotschna (227)	Malé Přítočno (27)	–127	–408	428	–63	145	158
Dolan (228)	Dolany (28)	–23	–251	252	108	32	112
Hostaun (229)	Hostouň (29)	–419	–407	584	–248	–130	280
Unt. Wesik (230)	Dolní Bezděkov (30)	134	372	395	–100	294	311
Ober Wesik (231)	Horní Bezděkov (31)	13	–156	157	–286	141	319
Braschkow (232)	Braškov (32)	–233	–128	266	–271	–172	322
Kischitz (233)	Kyšice (33)	–336	281	438	–238	213	319
Unhosst (234)	Unhošt' (34)	–261	475	542	–63	545	549
Gros Jentsch (235)	Jeneč (35)	–713	754	1037	–791	–168	809
Wuwno (236)	Humny (36)	217	–156	267	20	8	22
Hnidaus (237)	Hnidousy (37)	–535	743	916	316	333	459
Motitschin (238)	Motyčín (38)	–276	608	667	207	614	648
Trzin (239)	Dříň (39)	801	–47	802	325	231	399
				∅533			∅433

Table II. Comparison of differences in positioning the seats – test area Kladno

Transformations 39 identical points (4 identical points)	Mean position error m_p (m)	Average positional deviation d_p (m)	Extreme positional deviation $d_p^{\max}$ (m)
Müller's map – Basic map CR	598 (668)	533 (601)	1152 (1646)
First Military Survey – Basic map CR	472 (638)	433 (544)	1066 (1631)
First Military Survey – Müller's map	355 (400)	289 (323)	903 (1244)

dY (m) – difference in Y-co-ordinate

$$m_p^2 = \frac{dP^2}{n} \tag{2}$$

mp (m) – mean position error

n – number of points.

Table I contains the names of all the 39 settlements with their corresponding positional errors relative to the modern S-JTSK system positions (resulted from the transformation on 39 id. points). The overall results of both transformations (39 id. points, 4 id. points) for all the compared sets of points (settlement centres in the Müller's map, First Military Survey and the current Basic map of the CR) are presented in Table II.

Conclusions

The overall results of the two affine transformations presented in Table II confirm closer relation between the Müller's map of Bohemia and the First Military Survey — which may confirm assumed use of the Müller's map enlargements as a graphical base for the mapping. Positional deviations within the tested area are varying and no clear trends can be traced. The position of the town Jeneč (point 35) showed repeatedly one of the largest positional deviations within the set, therefore it may indicate a discrepancy in the position of this town depicted on old maps. The average positional deviations of points in Kladno region are smaller than in the test area in Southern Bohemia near Jindřichův Hradec (Mikšovský and Zimová 2005), where the average positional deviations for the points in old maps compared to the current Basic map were 100–200 m bigger.

The transformations done on only four identical points give the results probably not influenced so much by the least square adjustment, but of course the results depend on the selection of identical points. For more reliable findings it may be useful for future research to extend substantially the test area and/or to check the results using another kind of transformation apart from affine, for example the

Helmert transformation. The presented results may contribute to the attempts on investigating the positional accuracy of depicting objects on old maps of Bohemia of 18th century.

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Map resources: Historical Institute of the Czech Academy of Sciences (Müller's map of Bohemia); First Military Survey, Section No. 89 and 106, Austrian State Archive/Military Archive, Vienna; Geoinformatics Laboratory, University of J E Purkyne – http://www.geolab.cz; Ministry of Environment of Czech Republic – http://www.env.cz; Czech Office for Surveying, Mapping and Cartography (Basic Map of the CR).

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